computing for a better tomorrow

eCAADe 2018

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Lodz University of Technology

19th - 21st September 2018

Edited by

Anetta Kępczyńska-Walczak

Sebastian Białkowski

eCAADe 2018

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Volume 2

Editors
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Lodz University of Technology

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and Environmental Engineering
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Theme

Computing for a better tomorrow

This is the second volume of the conference proceedings of the 36th eCAADe Conference, held from 19-21 September 2018 at the Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology, Łódź, Poland. Both volumes together contain the 181 accepted papers that are also available digitally in CuminCad (Cumulative Index of Computer Aided Architectural Design, http://papers.cumincad.org/ or http://cumincad.scix.net).

The theme of the 36th eCAADe Conference is Computing for a better tomorrow. When we consider the aims of research activities, design efforts and mastering towards ideal solutions in the area of digital technologies in the built environment, such as CAD, CAM, CAE, BIM, FM, GIS, VR, AR and others, we may realise the actual reason for that is to make life better, healthier, prettier, happier, more sustainable and smarter. The usefulness of undertaken studies might be tested and proved by the noticeable shared approach of putting humans and their environments in a central position: man and the environment, nature and design, art and technology... Natural disasters and climate change, crime and terrorism, disabilities and society ageing - architects, designers and scientists active in the built environment domain are not able to eliminate all the risk, dangers and problems of contemporary world. On the other hand, they have social and moral responsibilities to address human needs and take up this multifaceted challenge. It involves a co-operation and, moreover, an interdisciplinary and user-oriented approach.

The complexity of raised problems should not discourage us, on the contrary, it should stimulate activities towards living up to human dreams of a better and sustainable tomorrow. This calls for a revision of methods and tools applied in research, teaching and practice. Where are we? What are the milestones and roadmaps at the end of the second decade of the 21st century? Do we really take the most of the abundance of accumulated knowledge? Or we skip to explore another undiscovered domains?
We invited academicians, researchers, professionals and students from all over the world to address the multifaceted notions of using **computing** in architectural and related domains for developing **a better tomorrow**. Approaches discussing the theme from the perspective

of computer aided design education; design processes and methods; design tool developments; and novel design applications, as well as real world experiments and case studies were welcomed. In order to specifically address some of the questions above, we defined subthemes and organised specific sessions around these subthemes, during the conference as well as in the proceedings.
Topics included, but were not limited to:

AI for design and built environment
Building Information Modelling
CAAD education
City modelling and GIS
Collaborative and participative design
Design concepts and strategies
Design tools development
Design and structure optimisation
Digital application in construction
Digital design for sustainable buildings
Digital fabrication and robotics
Generative design
Human-computer interaction in design
Information technologies in cultural heritage
Internet of things for built environments
Material studies
Parametric modelling
Shape, form and geometry
Simulation, prediction and evaluation
Smart and responsive design
Smart cities
Spatial reasoning and ontologies
VR, AR and visualisation

The first volume of the proceedings contains 87 papers grouped under 13 sub-themes while the second volume contains 94 papers grouped under 14 sub-themes. In addition to the accepted papers, the first volume is preceded by Keynote papers including keynote speakers contributions concerning the themes of their keynote lectures. Furthermore, it is enriched by special sessions papers and workshop contributions including the papers summarizing the ideas, goals and the content of workshops given.

Anetta Kępczyńska-Walczak
eCAADe 2018 Conference Chair

Acknowledgements

Welcome to the proceedings of the 36th eCAADe Conference and workshops, hosted by the Faculty of Civil Engineering, Architecture and Environmental Engineering at Lodz University of Technology, Poland, 17-21 September 2018. It has been exactly sixteen years since the previous eCAADe conference was held in Poland, organized at Warsaw University of Technology in 2002. We are now very happy to welcome you back to Poland, this time to the very centrally located city of Łódź.

The original idea of bringing the eCAADe conference to Łódź dates back to September 2014 after the eCAADe conference in Newcastle upon Tyne, England. Officially, the eCAADe Council granted us the permission to organize the 36th eCAADe Conference in Łódź in April 2015. Over the last four years several people have helped us to make this conference possible and it is our pleasure to acknowledge and thank them here. First of all, we would like to thank the former Dean of the Faculty of Civil Engineering, Architecture and Environmental Engineering, now the Vice Rector for University Innovations and Development at Lodz University of Technology, Professor Dariusz Gawin and the present Dean of the Faculty of Civil Engineering, Architecture and Environmental Engineering at Lodz University of Technology, Professor Marek Lefik for their positive and supportive attitude.
Secondly, we would like to thank the eCAADe Council, whose members have helped us with various aspects of the organizing. We warmly thank three following Presidents: Johan Verbeke (passed away in 2017), Joachim Kieferle and Tadeja Zupancic.
We thank especially Bob Martens for always kindly and promptly guiding us through the multistage arrangement process of the conference.
Furthermore, special thanks should go to the previous eCAADe organisers, Antonio Fioravanti and his team and Aulikki Herneoja for sharing their experience and knowledge.

Quality control is the vital issue concerning publishing of the conference proceedings. It was a requirement that abstracts were strictly anonymous and avoided any affiliations. To guarantee a high quality of submissions, additional formal checking had been provided before the reviewing process started. Thanks to eCAADe Council we were able to use the OpenConf system for abstracts submissions and reviewing process. Authors uploaded their extended abstracts (length of 1000 to 1500 words plus 5-10 references and one optional image) for the double blind peer review process. Each abstract was evaluated by three reviewers. With the

help of the OpenConf system we could easily ensure anonymity and that none of the reviewers came from the same institution as the authors. In this context, special thanks should go to Martin Winchester and Bob Martens for overlooking the abstract submission system (OpenConf), which is one of the main technical pillars for the preparation of this conference.

Altogether, we received a record number of 340 abstracts from 42 different countries. After the peer review process, 225 papers were accepted for full paper submission. In the end, altogether 181 papers were presented at eCAADe 2018 and published in the proceedings. We are very grateful for all the 128 reviewers from 31 different countries (see the List of Reviewers) for their constructive and thorough comments for each author. We also continued the practice started at eCAADe 2015 conference in Vienna of having all the session chairs to give prospective comments of the papers to evoke the discourse at early stage between the author and session chair for all sessions of the conference. We owe the reviewers and session chairs great gratitude for their commitment and long term contribution to the process until the final paper presentations. Parallel to these prospective comments editorial team gave comments to the authors too.
We thank and congratulate all authors for their hard work and support on using the ProceeDings tool and finalizing their full papers carefully in time. In this last phase of editing full papers we may not thank enough Gabriel Wurzer, Wolfgang E. Lorenz and Ugo Maria Coraglia of the ProceeDings team who enabled us to successfully produce high quality proceedings in time.

We owe great thanks to our Keynote Speakers: Antje Kunze (co-founder and CEO of the ETH-Spin-off CloudCities, Solution Manager for BIM and Smart Cities at Esri Germany), Tom Van Mele (co-Director and Head of Research of the Block Research Group, ETH Zurich), Krzysztof Ingarden (Professor at the Faculty of Architecture and Fine Arts, AFM Krakow University. President of Ingarden & Ewý Architects) and Harlen Miller (Associate Designer and practicing Architect at UNStudio's Amsterdam office, the Lead Coordinator of UNStudio's Computational Knowledge Platform) and their contributions of writing the keynote papers concerning their keynote lecture themes.

The roundtable session and panel sessions are traditional part of the scientific eCAADe event. This year the roundtable topic has focused on "A better tomorrow?" stimulating discussion and addressing the conference theme directly. Special thanks should go to Professor Tom Maver for chairing Round Table and to all panelists (Robert Aish, Urs Hirschberg, Antje Kunze, Harlen Miller and Martijn Stellingwerff). The special panel session was dedicated to Digital

Heritage and we are grateful to Bob Martens – the session moderator and all panelists, Laurent Lescop, Tom Maver and Takehiko Nagakura, for dynamic and fruitful dispute.
Workshops are integral part of eCAADe annual conferences. We pay our gratitude to all workshop organisers for fantastic work and contribution of short papers (see the list of workshops).
We are also grateful to Wolfgang Dokonal and the eCAADe Council for organizing the PhD Workshop for young researchers and supporting the grant winners with a subsidy for traveling to Łódź.
All additional activities are highly appreciated added value to the eCAADe conferences.

We would like to express our gratitude for the administrative help in organizing the conference, the eCAADe Council and especially Nele De Meyere. In this respect, special thanks should go to Joanna Konca, the Faculty Accountant, and Oliwia Łuczak for helping with financial issues.
As the eCAADe 2018 Conference Chair, I had support from the Organising Committee, especially Sebastian Białkowski, Mateusz Pankiewicz and Bartosz M. Walczak. I further want to give my thanks to Professor Piotr Liczberski, Dean of the Faculty of Technical Physics, Information Technology and Applied Mathematics, Lodz University of Technology, for co-operation in organising the place for the venue.

Organizing an international conference of this scale requires a lot of effort, also financially. Without our sponsors - Autodesk Inc., GRAPHISOFT SE, Vectorworks and Bentley Systems Inc., we would not have been able to offer the conference participants the level of quality that they have got used to at eCAADe conferences. As a special form of sponsorship, the members of the local conference staff donated their time to help prepare and organize this conference.
Finally, I would like to thank all students – volunteers who assisted us at the final stage of organising the eCAADe 2018 and during the event.

Thank you all for helping us out.

Łódź, 1st September 2018

Anetta Kępczyńska-Walczak
eCAADe 2018 Conference Chair

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Contents

ORe – A simulation model for Organising Refurbishments

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The problem of interferences due to the refurbishing activities of a complex building, carried out in parallel with the daily activities that characterize it, is not to be underestimated, especially when talking about a hospital structure. Consequently, the benefits that would be obtained by reducing the presence of construction activities result important in terms of safety and health of users, above all hospital patients. Setting the best solution of Gantt in the early stages of planning can be a winning strategy, as well as being able to recognize the safest and fastest path (e.g. predicting which is the fastest way to reach the rooms taken into consideration by the refurbishment). At the same time, being able to check which activities are most penalized by the presence of the construction site and to set which are essential for the survival of the activities that characterize the environment to be refurbished, e.g. the hospital ward, is a valid support tool for the healthcare staff. The proposed tool aims, on the one hand, to help designers by proposing the best possible Gantt solutions in relation to the management of daily activities that can not be suspended and on the other hand to support healthcare staff in the organization of these latter.

Keywords: *Refurbishment, Complex building, Construction site, Space syntax, Bubble diagram, Gantt*

INTRODUCTION

The main aim of this research is to propose a tool to support the organisation phase of the refurbishment showing to the professionals a classified list of best Gantt solutions according to their needs and the relative data supplied.

The refurbishment and modernisation of complex structures (e.g. schools, hospitals, airports, offices) are often in the condition of having to be carried out without having sufficient time to plan the relocation of activities and users at other locations [Ross et al. 2011].

Moreover, many activities of the construction site can be considered highly risky for the health of the users who are hosted by these structures (e.g. the immunosuppressed patients of a hospital ward are at high risk of fungal infections due to dust) or they can compromise the perfect performance of the activities (e.g. the loud noise can compromise a student's understanding of a teacher's lectures);

The complex structures already foresee by default an important series of safety procedures to be followed and which are to be intensified with the installation of a building site within them. If we talk

about hospitals, an example that can clarify the level of this problem is the following: a hospital aisle to comply with safety procedures is designed according to certain construction rules and its sharing/subdivision, on the construction site side creates the difficulty of ensuring the assigned part is hermetically sealed, while on the hospital side the narrowing of the corridor section can create problems both in the case of a strong flow of patients (e.g. emergency, fire) or for simple walking with a wheelchair or for traveling with the litters (the corridors of a hospital are sized to allow simultaneous passage in both directions).

STATE OF ART

The spread of the use of BIM helped professionals during the early design phase to reduce the geometrical interferences thanks to the clash detection [Eastman 1992] but in the context of refurbishment design for complex buildings (e.g. hospitals, airports, universities), the question of the logical-operative interferences between construction activities and daily operations, not to be suspended, it should not be underestimate. Therefore, being complex buildings characterized by multiple renovations activities, it is necessary to be taken as to ensure that work routines can take place in parallel to the construction work.

The main method to facilitate the continuity of the service of a complex structure (e.g. a functioning hospital structure) in the presence of a construction site inside it is the reduction of construction time. Among the various tools available, the Planning is indispensable, as it allows the multidisciplinary coordination between the different actors involved (e.g. hospital staff, workers, designers), providing for the partition of the project into steps and defining for each of them priorities, times, interconnections and resources. This work is schematized and outlined through a time schedule, which is highly recommended to be supported by a Gantt [Truffo 2008]. For these reasons our tool works to provide the best possible Gantt solutions based on the data provided at the beginning of the design phase and the needs of the organizers of the hospital activities. Indeed, through our tool, we have tried to expand the Gantt in order to allow a contemporary view of the construction site activities according to a sequential bar graph (typical of the classic Gantt) adding a planimetry that shows the areas involved in the refurbishment work, all according to the activities considered to be essential by the hospital staff.

METHODOLOGY

The main aim of our research is to reduce the negative impact of construction activities due to the long presence of those activities on the surrounding building environment where they are operating and, at the same time, due to the wasted time caused by interferences between those activities and the daily operations. Our workflow follows those 7 steps:

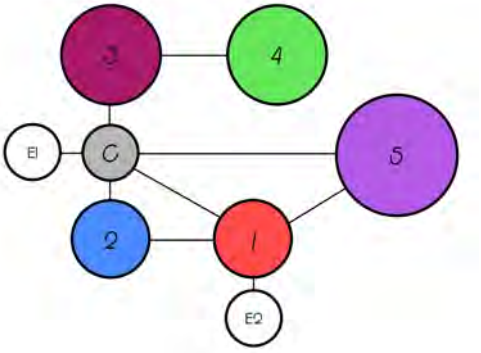


Figure 1
Bubble diagram

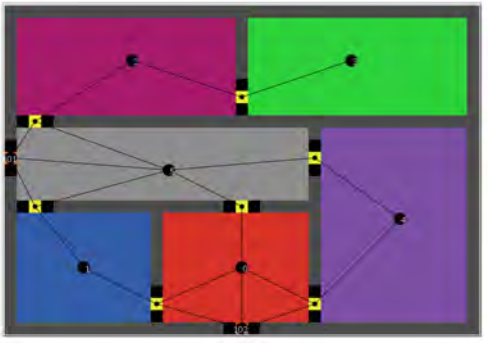
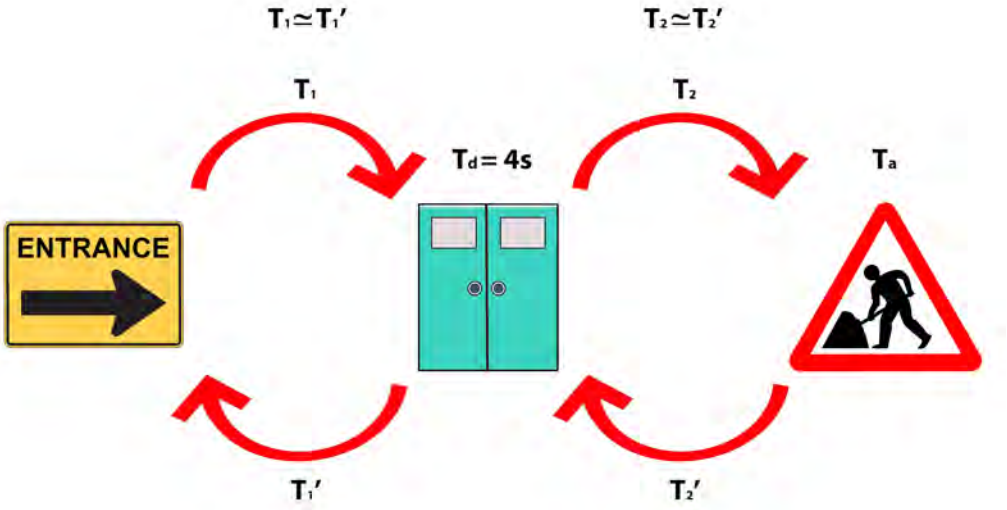


Figure 2
Connections

Figure 3
Simplified scheme of time related to path and activity



Step 1: From the spatial model to the schema, first of all we have to export a schema of each floor from BIM or CAD as bitmap of 1/3 [m] per [pixel];

Step 2: Import the schema, we analyse the bitmaps schema. Rooms are colour-coded (for each room and aisle a different colour was set). Moreover, each colour-coded-room is linked to a combination of daily operations. For example, in a ward composed of 5 rooms, the daily operation-colour-coded schema could be the following: Room 0 (red; operation A), Room 1 (blue; operations A and B), Room 2 (magenta; operations B and C), Room 3 (green; operation C), Room 4 (purple; operations C and D), Room 5 (light grey; aisle - connection), the Doors in Yellow and the Entrances in Orange;

Step 3: Bubble diagram. Starting from the schema we create a Bubble diagram by analysing adjacencies (see Figure 1). We look at the yellow cell (door) and connect these to the surrounding rooms. Moreover, we also take the entrances and connect them to the centre of the adjoining room or aisle. Furthermore, we connect entrances to adjoining doors if the distance of these is smaller than the distance to the room/aisle centre (see Figure 2).
In our case, using NetLogo software [Blikstein et al. 2005], through the setting of agents (called turtles) as activities and the connections between them (called links) we were able to do a paths analysis.
This step allows us to manage a lot of info in an effortless way to represent them graphically.
Analysing the diagram, we can find the topological relationship between rooms and aisles. Two rooms or aisles a and b ($a \neq b$) are one of: Adjacent (= connected by a door), touching (connected by a wall but no door), reachable via other rooms or aisles, Isolated (=not reachable because no path exists between a and b) [White 1986].

NB: the automation of this last phase will be taken into consideration for future works.

Step 4: From Paths analysis to Distance and Time analyses, adding the calculation of the shortest distance to tackle to connect different spaces [Wurzer

et al. 2011], e.g. rooms, aisles, we obtain the shortest time of impact due to the construction activities in the environments surrounding.
We can consider this step composed of 3 sub-steps. The first one, through the bubble diagram, allows obtaining the analysis of paths [m], considering all entrances (E1 and E2) as the starting points.
With the next sub-step, converting these data from distances [m] to time [s], we can obtain the table of times necessary to face these paths (the average walking speed is 1-1,5m/s but 1m/s is acceptable considering a male worker with a normal weight carrying a tool [Browning et al. 2006]). In the last one, adding also information related to the time to carry out activities (e.g. following a schema like this: Path - Door - Activity - Door - Path, calculated from both E1 and E2), defines the final table of the Times (distances and activities).

NB: to simplify, we considered the value of 10s for the transport activity of construction waste materials (Ta) and of 4s for the opening and closing of the door (Td) (see Figure 3).

Step 5: Setting up of exceptions, thanks to the topological relationships, our algorithm is capable of setting up the eventual exceptions that may emerge during the design phase between the different environments-functions (e.g. concerning to two rooms, A and B, in communication between them but with only the room A linked to the aisle, in case it is decided to start the refurbishment with the room B, we have to consider impassable also the room A because it will be occupied to the passage of workers and products from the aisle to room B and vice versa) or regarding the exceptions due to habits of construction activities (e.g. we can suppose the schema of the refurbishment of 2 rooms like Door A - Room A - Door A/B - Room B, it could become Door A - Room A - Room B, namely we could consider the Door A/B or locked as open or removed, depending on the construction activity. It would be right if we were talking about a standard construction site but, in our case, considering the special environment of a hospital without suspending its daily activities and therefore with the construction site very close to the users, especially patients, the doors were considered closed and open by workers only when necessary);

Step 6: From Bubble diagram to Gantt solutions, starting from the Bubble diagram and following the logic of Dynamic programming, our tool is able to compile all the tables regarding which rooms should be renovated before or in parallel with the others. Therefore, the algorithm outputs all the Gantt solutions feasible, depending on the settings of which activities as being required;

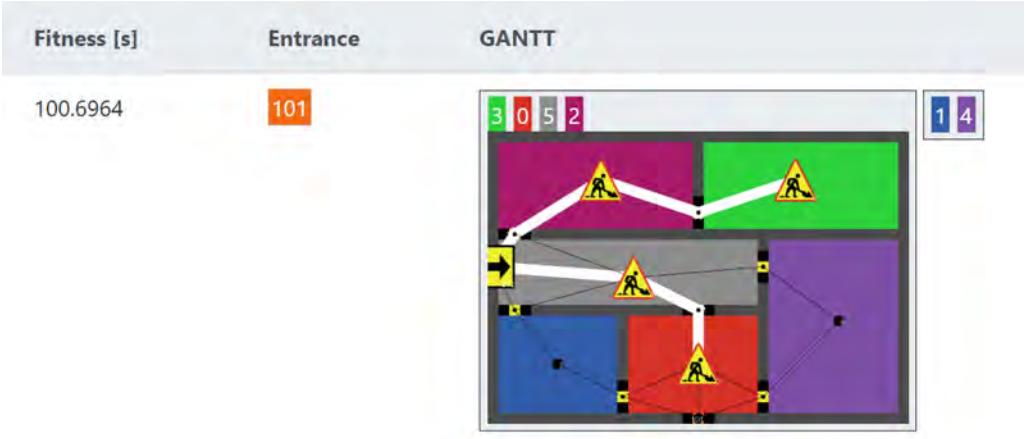
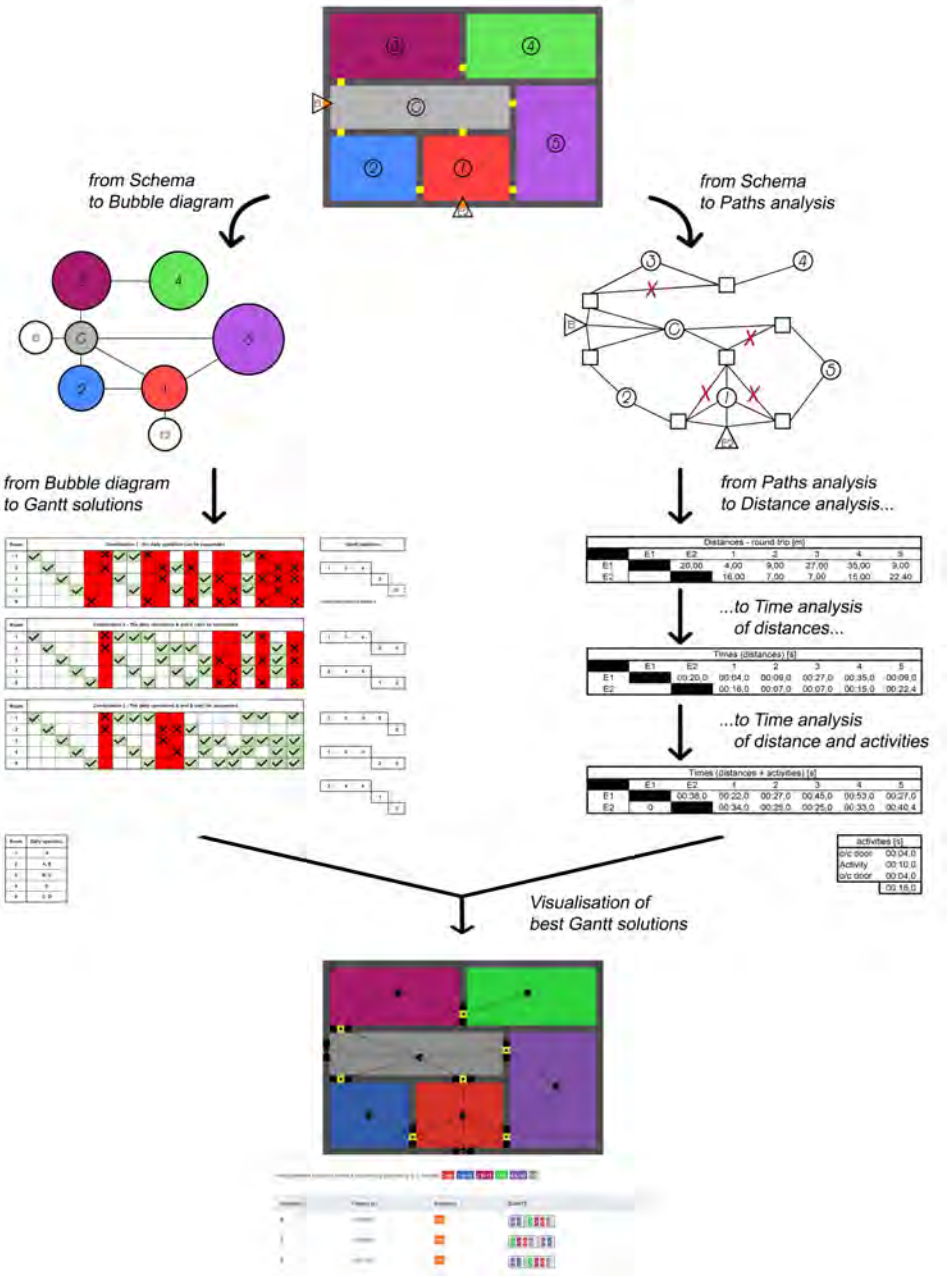


Figure 4
Visualisation of one of the best Gantt solutions

Figure 5
the whole workflow
algorithm



Step 7: Visualisation of best Gantt solutions, filtering all the Gantt solutions acquired in the previous step with the data of the times table through the cross-check, our tool is able to highlight and suggest, the list of best Gantt solutions, sorted by the shortest path (in seconds [*s*]), depending on which activities we set as not suspendables. This list is shown through a specific html page where every solution is accompanied by the entrance, selected for that solution, and the phases characterising it (visualisable on an additional screen) (see Figure 4).

The resume of our whole workflow algorithm is given in Figure 5.

CONCLUSIONS AND FUTURE WORKS

The aim of our tool is to reduce the wasted time and helps both hospital and construction staff to design a well-organised refurbishment, providing a list of the best Gantt solutions in terms of time, distances and expected activities.

The next step of our research will concern the implementation of the algorithm within the 3D environment, taking care of the relations between rooms not only on the same floor but also between different floors.

Moreover, through the interpolation of the Bubble diagram and the paths analysis, we will able to extrapolate the useful data to obtain from our tool an Adjacencies matrix automatically.

Furthermore, considering the context of refurbishment design of complex buildings and their maze of rooms and aisles, we evaluate extremely opportune to tackle the question of the interferences due to the reallocation of activities and tools (Staff & Stuff) in case of need of a temporary rearrangement in another place, in order to allow the correct carrying out of the construction activities and to ensure the continuity of services related to the daily operations.

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Index of Authors

When we consider the aims of research activities, design efforts and mastering towards ideal solutions in the area of digital technologies in the built environment, such as CAD, CAM, CAE, BIM, FM, GIS, VR, AR and others, we may realise the actual reason for that is to make life better, healthier, prettier, happier, more sustainable and smarter.

The usefulness of undertaken studies might be tested and proved by the noticeable shared approach of putting humans and their environments in a central position: man and the environment, nature and design, art and technology...

Natural disasters and climate change, crime and terrorism, disabilities and society ageing - architects, designers and scientists active in the built environment domain are not able to eliminate all the risk, dangers and problems of contemporary world. On the other hand, they have social and moral responsibilities to address human needs and take up this multifaceted challenge. It involves a co-operation and, moreover, an interdisciplinary and user-oriented approach.

The complexity of raised problems should not discourage us, on the contrary, it should stimulate activities towards living up to human dreams of a better and sustainable tomorrow.

This calls for a revision of methods and tools applied in research, teaching and practice. Where are we? What are the milestones and roadmaps at the end of the second decade of the 21st century?

Do we really take the most of the abundance of accumulated knowledge? Or we skip to explore another undiscovered domains?

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